Universidade do Porto

Faculdade de Psicologia e de Ciências da Educação

PSYCHOPATHY AND NON-LINEARITY OF FACIAL EXPRESSIONS OF EMOTION PROCESSING

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Mariana Rocha Pinto de Gonçalves Pereira

Junho 2014

Dissertação apresentada no Mestrado Integrado de Psicologia, Faculdade de Psicologia e de Ciências da Educação da Universidade do Porto, orientada pelo Professor Doutor **Fernando Barbosa** (FPCEUP).

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Resumo

A psicopatia é descrita como uma perturbação de personalidade associada a défices afectivos, interpessoais e comportamentais, como a falta de empatia ou remorso, capacidade de manipulação e condutas anti-sociais. O estudo do processamento de faces de emoção na psicopatia é uma temática comum, enquanto indicador e/ou justificação dos défices na afectividade e comportamento relacional. Porém, este não tomado na investigação enquanto um fenómeno dotado de um funcionamento não-linear. Deste modo, o presente trabalho procura estudar o processo de categorização emocional e de permanência perceptiva inerentes à maior prevalência de traços de personalidade psicopática.

Para este efeito, os participantes (n = 29) foram sujeitos a uma tarefa de identificação de perante imagens de faces, organizadas em *morphs*, isto é, *continuums* de faces (*frames*) que se vão progressivamente alterando de uma categoria emocional para outra, ou apresentadas aleatoriamente. As categorias emocionais usadas foram a Alegria, Tristeza, Medo e Raiva. As hipóteses desenvolvidas prevêem a maior remanescência do percepto inicial: (1) o índice de psicopatia está associado a maior efeito de histerese; (2) o índice de psicopatia está relacionado com um atraso na detecção do medo, comparativamente com outras categorias emocionais.

Os resultados apontam para uma relação entre os scores totais de psicopatia e a necessidade de mais *frames* para a detecção de Medo quando precedida de Raiva, o que representa uma remanescência da percepção de Raiva. Quando analisados independentemente os efeitos de cada sub-escala da psicopatia (*Boldness*, *Meanness* e *Disinhibition*), foi encontrada uma maior permanência do percepto de Raiva sobre Tristeza, atrasando a sua detecção, e uma correlação negativa entre a mesma e a detecção de Alegria quando precedida de Raiva. Assim, os resultados sugerem diferenças no processamento emocional com o aumento de alguns traços de personalidade psicopática, sobretudo no sentido da rigidez na detecção emocional quando sob o efeito duma percepção prévia e o uso de mecanismos mais superiores neste processo, culminando num mais acentuado efeito de histerese.

Palavras-Chave: Psicopatia, Processamento Emocional, Histerese

Abstract

Psychopathy is described as a personality disorder associated with affective, interpersonal and behavioral deficits such as lack of empathy or remorse, manipulation and antisocial behavior. The study of facial expressions of emotions processing in psychopathy is a common theme, as an indicator and /or justification of the affective and relational deficits. However, this research did not analyze facial processing as a non-linear functioning. Thus, this paper seeks to explore the process of emotional and perceptual categorization reminiscence in the higher prevalence of psychopathic personality traits.

For this purpose, the participants (n = 29) were asked to do an identification task of facial stimuli arranged in morphs, i.e. facial expressions organized in a continua (frames) that will progressively changing from one emotional category to another, or randomly presented. The categories used were emotional Happiness, Sadness, Fear and Anger. The hypotheses developed previewed this perceptual reminiscence: (1) psychopathy score is associated with a more salient hysteresis effect; (2) psychopathy score is related with a delay in the detection of Fear comparably to other emotional categories.

The results lead to the presence of a relationship between total psychopathy scores and the need for more frames to detect Fear when preceded by Anger's visualization, which represents a reminiscence of the perceived Anger. Also analyzed, the effects of each subscale of psychopathy (Boldness, Meanness and Disinhibition), the Boldness score showed a positive correlation with retention of Anger and a delayed detection of Sadness, and a negative correlation with Happiness detection after seeing Anger. Thus, the results suggest differences in emotional processing within the increase of some traits psychopathic, especially in the sense of rigidity in emotional detection under the effect of a previous perception and the use of superior and cognitive mechanisms in this process, culminating in a more salient hysteresis effect .

Keywords: Psychopathy, Emotional Processing, Hysteresis

Resumen

La psicopatía se describe como un trastorno de la personalidad asociado a déficits afectivos, interpersonales y comportamentales, tales como la falta de empatía o remordimiento, capacidad para manipular y presentar conductas antisociales. El estudio del procesamiento de rostros de emoción en la psicopatía es un tema común, empleado como un indicador y / o justificación de los déficits de afectividad y comportamiento relacional. Sin embargo, esta investigación no es considerada como un fenómeno dotado de una operación no-lineal.

De este modo, el presente trabajo intenta estudiar el proceso de categorización emocional y de retención perceptiva inherentes a la mayor prevalencia de rasgos de personalidad psicopática. Para ello, los participantes (n = 29) realizaron una tarea de identificación ante imágenes de caras organizadas en morfos, es decir, un continuo de fotogramas que iban cambiando progresivamente de una categoría emocional a otra o eran presentadas aleatoriamente. Las categorías emocionales utilizadas fueron alegría, tristeza, miedo y rabia. Las hipótesis desarrolladas predicen una mayor reminiscencia de la percepción inicial: (1) asociación de psicopatía con un más saliente efecto de histéresis; (2) asociación de psicopatía con la tardía detección de Miedo.

Los resultados señalan una relación entre los puntajes totales de psicopatía y la necesidad de más para detectar Miedo cuando está precedida de la Rabia, lo que representa una reminiscencia de percepción de rabia. Cuando se analizaron de forma independiente los efectos de cada sub-escala de psicopatía (Boldness, Meanness y Disinhibition), fue encontrado una mayor retención de la percepción de la Rabia sobre la Tristeza, retrasando su detección, y una correlación negativa entre el mismo y la detección de Alegría cuando estaba precedida de la Rabia. Por lo tanto, los resultados sugieren diferencias en el procesamiento emocional con el aumento en algunos rasgos de personalidad psicopática, especialmente en el sentido de rigidez en la detección emocional bajo el efecto de una percepción previa y el uso de mecanismos superiores en este proceso, refletando en un mayor efecto de histéresis.

Palabras clave: psicopatía, procesamiento emocional, histéresis

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Introduction

1. Defining Psychopathy

The concept of psychopathy has been evolving over the years, becoming more complex and comprehensive. Nowadays, it can be defined as a personality disorder that compiles affective, antisocial and lifestyle features such as manipulation, lack of empathy or guilt, deception, and unethical and stimulation-seeking behaviours, which can or cannot include criminality (Hare & Neumann, 2006).

The interest on this concept can be explained by, in one hand, the challenge that it represents for the study of basic emotional and behavioural processes, and, on the other hand, the impact of psychopathic behaviour on the social functioning (Patrick, Fowles, & Krueger, 2009). The first laboratorial approaches to psychopathy were done on the 50's and were mainly focused on the psychophysiological functioning of these individuals. One of the greatest examples of this era was the work by Lykken (1957), classified as one of the first etiological theory of psychopathy, which will be discussed further. Currently, most literature consists of molecular neuroimaging and neurophysiological-based studies (Fowles & Dindo, 2006; Almeida, 2012).). Although this experimental approach is recent, the first concepts of psychopathy, or of disturbs that had inspired the contemporary notion of it, may be traced back to the XIX century.

The first reference to psychopathy was done by Phillipe Pinel, who defines it, similarly to Pritchard in 1837, as "insanity without delirium", present in impulsive and violent individuals (Patrick, 2010). Over the history, other authors have defined psychopathy, simultaneously creating different approaches to the theme and keeping the combination of mental illness and aggressive behaviour at the same time, as Pinel said. The most important classical influence on the present day conceptualization is Hervey Cleckley and his book "Mask of Sanity" (1941; 1976). Cleckley suggested 16 representative features of psychopathy, making him one of the first and most significant authors to conceive it as a personality disorder and to line it off a violent conception - nine of these points concern personality traits, like superficial charm, lack of sincerity, lack of remorse, or

egocentricity; and the others are related to actual behavioural aspects, like impulsivity, that obviously emerge from the personality and internal characteristics. This merge of personality traits and behavioural traits is still present in modern conceptions (Rogers, 2006).

His concept of psychopathy, or "masked personality disorder or defect" (Cleckley, 1976), is based upon the rational capacity possessed by these individuals to imitate robotically the social and emotional experiences that are present on the general people's lives, due to their inability to truly experience them, exhibiting therefore a mask of sanity. There are several aspects of this theory which remained in the current definitions, especially the moral and emotional deficits as the central characteristics of this personality and the presence of traits that enable the existence of successful psychopaths, instead of the associations done by every earlier definitions between psychopathy and mental illness and criminality.

Despite all efforts, psychopathy is still a growing and evolving concept, resulting from every classical influences and aggravated by the constant link to other clinical disorders, such as AntiSocial Personality Disorder or, in earlier stages of development, Conduct Disorders (Almeida, 2012). Thus, literature is not consensual and a multiplicity of definitions naturally leads to a plurality of descriptive and explaining models of psychopathy

1.1. Modern Conceptions and Models of Psychopathy

On the last few decades, several authors have developed conceptual models of psychopathy that differ in numerous aspects: the choice of a factorial or dimensional structure; the characteristics that are considered central; the possible subtypes that may emerge.

The most recognized early formal model was born in 1980, by the work of Robert D. Hare, alongside with the development of an assessment instrument, the Psychopathy Check-List (PCL; Hare, 1980), posteriorly reviewed in 1985 and 1991. Hare's perspective supports the existence of two major inter-correlated factors on the construct of psychopathic personality (Hare & Neumann, 2006). Factor one is related to interpersonal and affective aspects, conferring to the psychopath his emotional hypo-reactivity and predatory inclination, and it is represented by items such as superficial charm, shallow affect, lack of remorse and manipulation. Factor two represents its behavioural facet, like

lifestyle and anti-sociability, assessed by the presence of parasitic lifestyle, impulsivity, irresponsibility or early behavioural problems. In 2007, this model was reviewed and complexified into a four-factor model, where we can still find this two basic factors but now divided into Interpersonal factor and Affective factor, and Lifestyle and Anti-sociability, respectively, shown on Fig.1 (Hare & Neumann, 2008).

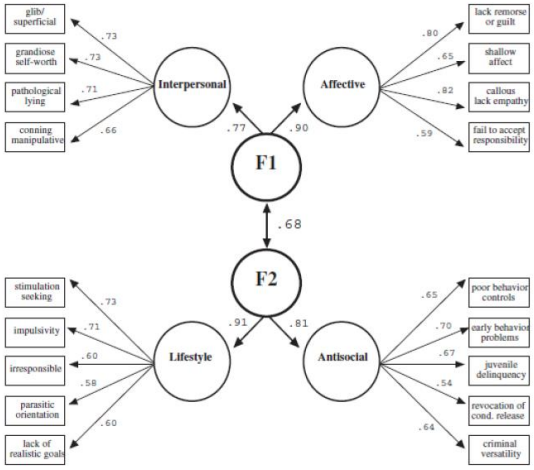

Fig. 1 Four-factor model of psychopathy (in Almeida, 2011, originally reprinted from Hare & Neumman, 2008)

The model developed by Hare is still present nowadays in many conceptions of psychopathy, being relevant not only to clarify this concept and representing one of the most consensual definitions of the phenomenon, but also to inspire new models that try to bridge eventual gaps. One of the main criticisms concerns its categorical vision of psychopathy. Christopher Patrick (2006), one of the most pronounced critic of this model, remarked that " not all individuals classified as psychopathic according to Hare's diagnostic criteria presented the same way clinically" (pp. 14), showing the complexity of this disorder and unveiling his vision of it as a probabilistic combination of traits. The second biggest flaw is the lack of explanatory power of successful psychopathy, not only for only being supported and tested only in criminal samples, as well as the absence of any items of positive adjustment of these individuals (Almeida, 2012; Patrick et al., 2009). Therefore, and based on Cleckley's conception, Patrick (2206) stands for a need of a model that can include: behavioural deviations, lack of social and emotional competence and indicators of well-adjustment.

In order to achieve this goal, Patrick, Fowles and Krueger, in 2009, presented the triarchic model of psychopathy, which assumes the existence of three phenotypical

components that result from the interaction between child's temperament and environmental influences. One of those components is "Disinhibition", described as a propensity towards impulsive behaviour, future-planning deficits, emotional regulation problems and search for immediate satisfaction, in other words, it explains the impulsive antisocial behaviour and, when present, substance use and criminal conduct. This phenotype has been consensual through all contemporary psychopathy conceptions, like Hare's, but, as referred by the authors, "it is when externalizing tendencies are coupled with dispositional boldness or meanness that a diagnosis of psychopathy would be considered applicable" (Patrick et al., 2009, pp. 926). Another component is "Meanness" and is related to the affective deficits, such as lack of empathy, difficulty in establishing and maintaining long and intimate interpersonal relationships or empowerment by cruelty. In terms of manifestations, this phenotype is associated with arrogance, manipulation, challenging authority, cruelty towards people and animals, and is considered as central to the development of criminal and delinquent conduct. Concerning the two phenotypes described until now, Patrick and his colleagues link their development to three major factors: difficult temperament of the child, which involves irritability, attentional deficits, and deficit in adapting to environmental changes, raising the propensity towards conduct disorders and the impairment of processes like socialization; lack of secure attachment, that plays a central role on the future relationship pattern; and the presence of coercive exchanges between parents and the child, that, when successful on extinguishing parental demands, can be generalized to pairs and teachers, which contributes to the degradation of these relationships and subsequently promoting the alliance to deviant pairs and antisocial conducts. Actually, the literature privileges early parental experiences, like the work done by authors like Frick and Morris (eg. 2004). However, "Meanness" can also be explained as influenced by the genotype "Fearlessness", related to a genetic disposition of these individuals towards low physiological reactivity to stressful or dangerous events. The authors submit that, while existing a difficult temperament and low-fear, if parenting practices are not positives and if other risk factors are present (e.g. abuse), this genotype will evolve into the development of "Meanness". Yet, with positive parenting influence, the child can apprehend a more social adaptive behaviour, following a pathway of "Boldness" instead. This last phenotypical characteristic can be defined as the ability to maintain calm in more threatful or stressful situations, manifesting as courage, assertiveness and social dominance. Below is presented a scheme showing the three

phenotypes that compose this model (circles), their possible overlaps and the dispositional factors that influence them (arrows).

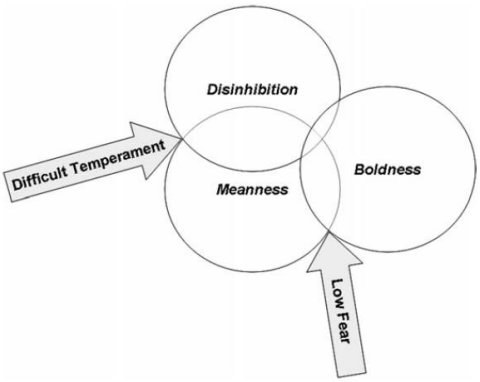

Fig. 2 Scheme of the Triarchic Model of Psychopathy and its etiological influences. Reprinted from Patrick, Fowles and Krueger (2009)

Patrick and colleagues (2009) consider that this model bridges the gaps of the previous ones, since the three phenotypes can explain all of psychopathy manifestations "criminal and non-criminal, primary and secondary, stable and aggressive, unsuccessful and successful" (in Patrick et al., 2009, p.925). Due to this more comprehensive approach, this will be the base-model of the psychopathy conception of the present work, justifying as well the use of the instrument proposed to operationalize the model's three constituents, the Triarchic Psychopathy Measure (TriPM; Patrick, 2010), a self-report scale to assess the individuals psychopathy levels in a dimensional way.

1.2. Etiological Theories

Thanks to the previous interest on the study of psychopathy, on the last 15 years there is a bigger concern on finding the developmental basis of psychopathy and what may be done to prevent it (Patrick et al., 2009). Therefore, numerous factors were found that, when conjugated, seem to influence psychopathy, from genetic, environmental, neuroanatomical to neurochemical factors. Despite this wide range, it seems legitimate to say that all these influences culminate on neural development and function changes, and so all etiological models relate psychopathy with a deficit of cognitive or emotional order, or

behavioural disorders, as impulsivity or anti-sociability, each one associated with specific brain structures.

The first known etiological theory is Lykken's (1957) "Low-Fear Hypothesis", improved afterwards in 1995, and it suggests an inability in experiencing fear and anxiety as the central disorder of psychopathy. Moreover, the concept of psychopathy which supported Lykken's perspective was the theoretical work developed by Cleckley and his concept of "primary sociopath", whose central characteristic was an impaired emotional resonance. The initial approach to this issue was made by using self-report scales, where primary psychopaths scored lower than controls in the *Activity Preference Questionaire* (APQ), which may be interpreted as a lower experience of anxiety in the perspective of stressful events (Lykken, 1957; Fowles & Dindo, 2006). At a psychophysiological level, the 1957 study reported electrodermal hypo-reactivity in an aversive conditioning protocol working as an explanation to the previous results of less reactivity to the items that were related to more dangerous or stressful situations and to the worse results on the reward-oriented avoidance learning task, where psychopaths showed some difficulties on avoiding the error, and consequently the punishment, (Lykken, 1957). Inspired by these findings, more authors dedicaded their investigations to verify the existence of other learning deficits in psychopathy beside those in conditioning and avoidance learning, and all of them, complemented and supported primarily by Lykken's results, predicate differences on central and autonomous nervous systems on these individuals, comparatively to controls (Fowles & Dindo, 2006).

Another etiological theory is the "Frontal Lobe Dysfuncion" (e.g. Gorenstein & Newman, 1980). Studies relating frontal functioning and psychopathy arise mainly associated with impairments on moral and social behaviour, deficits in emotional recognition, aggressive and criminal behaviour and learning deficits. These are considered as central to the concept of psychopathy and are related mostly with the prefrontal portion of the cortex (Almeida, 2012). Initial association between frontal lobe dysfunction and psychopathy was done on the 80's by Gorenstein and his systematic analysis of several neuropsychological results in psychopathic offenders and other literature concerning frontal functions. Here, the author suggested a link between disruptions of a circuit that include, beside other structures, the frontal lobe, and disinhibition in psychopathy (Gorenstein, 1982). Several authors also used neuropsychological tasks to evaluate frontal functioning in psychopathic offenders, and all results suggest an association between frontal lobe dysfunctions and the antisocial characteristics of psychopathy – PCL's Factor

two (Rogers, 2006). Affective aspects of psychopathy, are also related with this region, especially its orbital aspect, namely involved in representation of emotional information and motivational processes (Phillips, Drevets, Rauch & Lane, 2003). Some other behavioural and cognitive aspects, mentioned above, were extensively enlightened by Rolls' contributions of PFC and OFC, involved in decision-making processes, adaptation of behaviour to environmental contingencies, ability to reverse behavioural strategies through new learnings and facial expression discrimination (Rolls & Grabenhorst, 2008; Rolls & Treves, 1998; Rolls, 1999).

The following etiological theory considers psychopathy as an emotional and moral developmental deficit. Considered as one of the most complete explanatory theories of this syndrome, the amygdala dysfunction theory is primarily and mostly, until today, defended by Blair. On 1995, this author presents a new explanation that tries bridge the gaps of the previous etiological theory, the "low fear hypothesis", such as the fact that this doesn't associate the deficits with some specific neurophysiological/structural causes or by considering that socialization is a learning process that only develops through punishment. The hypothesis offered by Blair as a cause of psychopathic behaviour, i.e. mainly empathic deficits that influence the development of morality and socialization, impairments on the Violence Inhibition Mechanism (VIM). The VIM (in Almeida, 2011), is a theoretical control mechanism to manage intra-specific aggressive behaviour in social animals through the detection of submission and vulnerability clues on the other individual. In humans these cues are suggested to be the by facial or auditory traces of sadness or fear in others (Blair, 1995). Assuming this, impairments in the VIM's explain mostly the lack of resonance caused by suffering in others, or other negative emotion, and the deficits found on the identification of facial expressions of fear. Blair recognized the limitations of this etiological model, and therefore, paired with Mitchell and Blair (2005), proposed a new model to repair specially gaps detected at the cognitive and neural levels. The "Integrated Emotional System (IES) – "represents a neurocognitive model of the interactions of the systems involved in emotional processing" (pp. 425, Blair, 2006a). As it involves other structures that are related with amygdala complex, this model also considers ventrolateral and orbitofrontal portions of prefrontal cortex, especially related to response reversion and extinction and mediation and regulation of emotional behaviour, connected to antisocial conducts and reactive aggression. The greatest importance of this model is its focus on presenting specific, and endophenotypical, neurophysiological correlates, merging the

influence of other factors like genetic load for the transmission of psychopathic traits and or neural consequences of environmental influences

Lastly, on the Response Set Modulation model (Newman, 1998) addresses cognitive issues and atencional deficits, assuming disinhibition as a central characteristic of psychopathy. This characteristic is assumed to be related to impairments on the Septal-Hippocampus-Orbito Frontal Cortex axis, associated with response suppression mechanisms after environmental changes, impulsive behaviour and inability to process peripheral information , in attentional-shift terms. The worst results manifested by psychopathic individuals in emotional detection tasks can be then explained by the commonly peripheral nature of this type of stimuli. IN fact when instructed to pay attention to the central aspects of emotional faces stimuli, psychopaths normalize their answers (e.g., Glass & Newman, 2006). This model also addresses thepoor results in avoidance learning tasks, suggesting that it is an attentional deficit that can be solved by the absence of a time-limit and so allow them to make a more rational and cognitive choice before they answer.

2. Processing of Facial Expressions of Emotion : Conceptualization

Facial processing is a long-time investigation topic, fundamentally due to its precocious appearance developmentally and its social relevance.

Earlier in experimental investigation, faces were considered as equal as any other visual stimuli. However, it has been found over the years that faces carry specific perceptual significance and therefore are processes relying on specific cognitive and neuronal processes and substrates (Ferreira-Santos, 2013).

We can define facial expressions as “specific configurations of the facial muscle activity, often elicited automatically as a part of an emotional response” (Ferreira-Santos, 2013, pp.22), that can communicate intentions and emotional states. Each emotion has a specific pattern of activation of Facial Action Units (FAU, Ekman & Friesen, 1976), that combined in specific sets leads the receptor to elicit appropriate responses (Aguado, Valés-Conroy, Román, Diéguez-Risco & Fernandez-Cahill, 2012), which proves its social function.

The complexity of facial processing matches the complexity of facial stimuli, as these are composed of both stable and changeable properties. Therefore, when processing facial expressions, at least two types features are analysed, concerning identity and emotional aspeccts (LaBar, Crupain, Voyvodic, & McCarthy, 2013). Bruce and Young (1986) extend facial content to seven types of information: (1) pictorial; (2) structural; (3) visually derived semantic; (4) identity specific semantic; (5) name; (6) expression and (7) facial speech codes. Each of them seems connected with specific neural networks and regions.

The nature of facial processing is still a very much discussed issue in literature, although one of the strongest perspectives about it is that they are discrete entities, as well as emotions (Dailey, Cottrell, Padgett, & Adolphs, 2002). Ekman (1999) suggests that each emotion has a specific pattern of psychophysiological correlates and mechanisms of response, mostly manifested through prototypical facial and body features. Therefore, assumed as discrete, two expressions belonging to two different emotional categories (e.g., fear vs happiness) are more clearly distinguishable comparably to two expressions belonging to the same category. This phenomenon is called Categorical Perception (CP; Harnad, 1987). Stevan Harnad is the author of CP's conceptualization and in his chapter "Categorical Perception: The Groundwork of Cognition" (1987), he asks which are the psychophysiological mechanisms involved in this process and which are its main characteristics. As Kikutani, Roberson and Hanley refer (2010), Harnad considered categorical perception as the phenomenon "when a continuous change along a perceptual dimension comes to be judged as a series of discrete qualitative regions separated by sharp boundaries between labelled categories" (pp. 886), making this gradual change perceived as an abrupt switch from one percept/category to another instead of a continuous fashion (Dailey, Cottrell, Padgett, & Adolphs, 2002; Hartendorp et al., 2010). The influence of certain categories on perception can be seen by the fact that, as we saw above, it seems easier to discriminate stimuli from different categories then different stimuli in the same category, even when the physical differences between them are kept equal (i.e. when the distance between them in terms of continuum is the same) (Holmes & Wolff, 2012; Leppänen, Richmond, Vogel-Farley, Moulson & Nelson, 2009). This is explained by its nearness to the category boundary (Goldstone, 1994; Kikutani, Roberson & Hanley, 2010).

This boundary effect is widely studied in literature, especially with morphed stimuli in AB-X discrimination tasks (e.g. Angeli & Gerbino, 1997; Beale & Keil, 1995; Calder, Young, Perret, Etcoff & Rowland, 1996; Kikutani, Roberson & Hanley, 2008; Kurakova,

2011), where participants should detect whether a stimulus X is equal or alike A or B. This experimental paradigm is actually one of the mostly used to study facial perception as a categorical phenomenon. The first authors that adresse the perceptual mechanisms underlying facial perception were Etcoff and Magee (1992) using this type of stimuli and paradigm. These authors, and others that replicated and were inspired by their study (e.g. Calder et al., 1996; Young et al., 1997), found that the perception of facial expressions is an example of CP, showing that although the morphed continuum represents a linear transition between two expressions, its identification is done in a nonlinear pattern, changing abruptly from one category to another in some point of the continuum (Leppänen, Richmond, Vogel-Farley, Moulson, & Nelson, 2009).

It is still not clear what are the determinant factors that contribute to define the boundaries between each category, but a study by Fujimura, Matsuda, Katahira, Okada and Okanoya (2012) found that CP occurred when a certain facial expression in a morphed set of stimuli alters its valence and/or arousal values significantly, leading to a change of percept to the next emotional category visible. This work actually brings closer the two different possible approaches to emotions – dimensional and categorical . Young and colleagues already had suggested in 1997, showing that face perception gives respect to these two types of values (and therefore processes) involved in emotional processing (Fujimura et al., 2012).

Due to face processing complexity, it has been proposed the existence of an extended neuronal system involved in it. Obviously, there are some major areas that constitute the core system of facial processing given the fact that faces are a visual stimuli: inferior occipital gyrus, related to perception of visual features; fusiform gyrus, related to stable aspects like identity; superior temporal sulcus, responsible for changeable aspects, where emotional content fits (Ferreira-Santos, 2013; Haxby, Hoffman & Gobbini, 2000). This is however far from being consensual, as the emotional expression modulates the functioning of fusiform gyrus as well (Vuillemlier, Richardon, Armony, Driver & Dolan, 2004). As regions that seem to be specific to this type of stimuli, Haxby and colleagues (2000) define them as part of an extended system, composed by intraparietal sulcus, amygdala and insula, auditory cortex and anterior temporal lobe, which are related to spatial attention, emotional, speech perception and memory recognition, respectively. This constitutes neural proof to the diversity of information that can be decoded in a facial expression of emotion, as defended previously by Bruce and Young (1986).

Subsurving these areas, there are two major visual pathways: the retina-tecto-pulvinar (TP) and retina-geniculo-striate (GS) (Kosslyn, 2010). These are related to the processing of information with different visual time and spacial resolutions (Almeida, 2012). The tecto-pulvinar is a subcortical stream that projects retina's inputs to the superior colliculi, which communicates with the pulvinar, a thalamic nucleus that will act as hinge to the spreading of the information to other parts of the cortex, as parietal lobe and amygdala. In terms of function, the tecto-pulvinar pathways seems to contribute to orienting one towards a stimuli and motion perception (Lyon, Nassi, & Callaway, 2010), while the geniculo-striate pathway is related to pattern and object identification (Kosslyn, 2010). The geniculo-striate pathway, the mostly used via on the first developmental stages (Johnson, 2008), passes through the lateral geniculate nucleus from the thalamus and projects then to occipital lobe's visual areas. Both pathways are demonstrated on Figure 3.

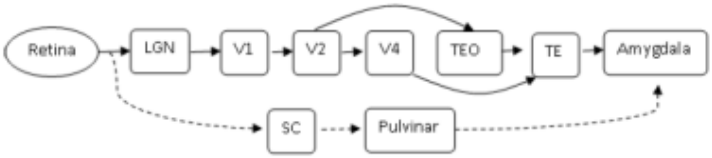

Fig. 3 Schematic representation of the two major visual pathways. Tecto-pulvinar is represented by a dashed line and geniculo-striate via is in a full line. Reprinted from Almeida (2011)

Their existence is proved mostly by behavioural findings showing that individuals can still detect and identify objects even when one of the structures of one pathway is compromised (de Gelder, Vroomen, Pourtois, & Weiskrantz, 1999; Morris, 2001). The differences between both pathways are especially relevant when considering the processing of facial expressions of emotion, due to the specificity of these visual stimuli. As referred and represented in Figure 3, the TP is a faster pathway to amygdala and is commonly associated to non-conscious perception of emotional stimuli, esspecially fear (Liddell et al. 2005; Morris, Ohman, & Dolan, 1999), eliciting fastest facial and pupillary response when compared to conscious the conscious processing of stimuli (Tamietto et al., 2009), while the GS, a more cortical pathway, is related to conscious perception of emotion (Williams et al., 2006). Combined with its speed, the association of the TP with emotional processing is also because of one of its structures, the pulvinar. As reviewed by Padmala, Lim and Pessoa (2010), this structure is involved in relevant features analysis and is dependent on attentional resources and awareness processes, and its medial portion is relevant in

evaluating the behavioural and biological relevance of the stimuli. Therefore, with all the evidences, it seems that emotional information is processed in a faster way than any other visual stimuli (Pessoa & Adolphs, 2010).

Categorical perception's neurophysiological mechanisms are still under study. One of these issues is the understanding of its association with left-hemisphere processes, and notably with language. (e.g. Goldstein & Davidoff, 2008; Roberson & Davidoff, 2000; Roberson, Davies, & Davidoff, 2000; Zhou et al., 2010). This turns categorization into a linguistic phenomenon, although recent studies suggest that it might be a non-linguistic phenomenon (e.g., Goldstone & Hendrickson, 2010). As reported by Holmes and Wolff (2012), some of these studies using unlabelled categories also found a left-lateralized CP and secondly some authors found categorical processing in prelinguistic children and animals.

The notion of a specific category for each emotion is also supported by neurophysiological findings of distinct pathways and regions used in specific emotions recognition (Calder et al., 2001).

Although automatic in nature, facial perception leads to some cognitive processing that involves, as it represents a categorization task of ambiguous stimuli, the interference of top-down processing aspects such as attention, recognition and voluntary control (Sterzer, Kleinschmidt & Rees, 2009). As Marsh and Blair noted, identifying any emotional expression is a complex task, including "visual scanning, perceptual processing, effortful attention, working memory and semantic processing" (Marsh & Blair, 2008, pp.462).

2.1 Face perception as a non-linear phenomenon

As reviewed above face processing does not seem to be a linear task in cognitive and neural terms. It can be considered as a non-linear process, sharing properties with dynamic systems, which theory has been recently used as an explanation hypothesis of cognitive functioning (Camras & Witherington, 2005; Port, 2000; Witherington & Crichton, 2007).

The concept of dynamic system was born in mathematics and can be defined as the result of the interaction of three fundamental elements: (1) *actual state*, which represents all variables that describe the system at the moment*;* (2) *time*; and (3) *evolution rule*, responsible for the preview of system's future state, according to both actual state and external influences (Basset, 2012; Beer, 2000; van Gelder & Port, 1995). This rule can be

deterministic, when it is only possible a single future state, or stochastic if there is more than one possible path to the system's evolution and therefore more than one possible outcome state, making it unpredictable. In that last possibility, we are before a non-linear dynamic system, where a problem (in this case, the definition of future state) cannot be solved just by a simple adding of its components (Miller, 2008). Even though its randomness, and accordingly to this theory, the evolution of dynamical systems is sensitive to initial state and it is permeable to both internal and external changes. Thereby, although its several possibilities of progress, a dynamical system will tend to evolve into a certain set of potential future states, called *attractors* (Stadler, Ricther, Pfaff & Kruse, 1991). Altogether, a dynamic system should present an actual state and with the time evolution, following the internal changes of the system or external influences, it should change its state abruptly, due to the lack of adaptation of its actual condition to the new circumstances (Beer, 2000). This abrupt change is addressed by the Catastrophe Theory, created by René Thom (1972). Here the author explains that dependent variable changes can be the result of smooth variations in the independent variable which leads to sudden changes on the variable's relationship, called "catastrophies" (Stewart & Peregoy, 1983). Non-linear properties may result in a phenomenon termed multistable stimuli, i.e. when a stimulus can have more than one perceptual organization (Attneave, 1971). This phenomenon is illustrated in two of the most relevant studies in the area, by Fisher in 1967 and by Poston and Stewart on the 70's, using ambiguous stimuli, in this case morphs that would evolve between a man's face or a kneeling girl or on the contrary order. Participants were required to say which was being presented through a set of eight frames, where it was possible to see the image changing progressively (Poston & Stewart, 1978). The behavioural data shows a response pattern where the first percept seems to persist in time, usually until half of the whole spectrum of frames, even though the major characteristics of the image are already lost. Posteriorly, a sudden and abrupt change happens in the classification of the percept. The described phenomenon is an example of another related concept, born from physics, called Hysteresis, associated with the functioning of dynamical systems (Kelso, 1995) and with perception of ambiguous stimuli (Hock, Kelso & Schöner, 1993; Hock, Bukowski, Nichols, Huisman & Rivera, 2005). The perceptual hysteresis effect may be defined as a phenomenon where the initial percept of an object is created and persists in time, although its parameter's values favour another alternative percept, which will be reached later (Hock, Kelso & Schöner, 1993). Therefore, in tasks with multistable stimuli like morphs, we can consider visual system, or more specifically facial perception, as an

example of a non-linear functioning, since we are able to categorize a certain facial expression through an initial perception, and then, as it changes to a different expression (changing of extrinsic parameters), the initial percept tends to persist. The emotional category doesnot change until it is clearly demarcated from the previous one (e.g. Hock et al., 1993), when the abrupt change happens, phenomenon explained by catastrophe theory presented earlier.

Crossing it with categorization phenomenon, the first percept and the following abrupt perceptive change occurs when the stimuli assumes usually its extreme parameters, which in facial expressions is related to its prototypical form or close to it. For that reason, being categories perceived as independent entities with limited and well-defined boundaries, the perceptive system is more sensitive to changes around these boundaries comparatively to changes in the same category (Calder, Young, Perrett, Etcoff, & Rowland, 1996), explaining percept change's timing.

3. Emotional Face Processing in Psychopathy

The processing of facial expressions of emotions in psychopathy is a wide research topic, assuming more preponderance in this new millennium. However, its results are not consensual. Some studies refer that there are deficits in emotional facial processing, being mentioned general impairments, i.e. in every emotional category (e.g., Hastings et al., 2008) or specific to certain emotional categories like sadness and fear (e.g., Blair et al., 2001, 2004, 2008) or disgust (e.g. Stevens et al., 2001). There are also several researches that found no difference between psychopaths and controls (e.g. Glass & Newman, 2006; Hansen et al., 2008), or even find an enhanced emotional processing in these individuals (e.g. Book, Quinsey & Langford, 2007; Kosson, Suchy, Mayer & Libby, 2002).

There are three major meta-analysis about emotional processing in psychopathy, mostly concerning perception of facial perception of facial emotions, that are already good examples of this variability. Marsh and Blair (2008) have found a significant relationship between anti-social behaviour and impairments in recognition of sad, surprise but greatly of fearful expressions. They mention that these deficits in fear recognition may be associated with specific neurocognitive mechanisms, namely involving the amygdala (Adolphs, 2002), a subcortical structure related with emotional processing and showing

enhanced activity through fear processing in healthy subjects, as shown by Murphy, Nimm-Smith and Lawrence (2003), but hyporeactivity in some samples (Corden et al., 2006). Although not specifically focused in psychopathics traits in general, this meta-analysis shows that the most related factors to fear recognition deficits are possibly the amygdala impairments and the anti-social behaviours, which overlap psychopathy characteristics (Marsh & Blair, 2008).

Wilson, Juodis and Porter (2011) also presented a meta-analysis about emotional processing in psychopathy, specially focused in fear and loathing. The authors were interested in understand if the variability of results found in literature were due to factors like response type, or some sample characteristics, including age. They have found that there were small deficits in every emotional category, with a significant effect size just for fear and sadness, also referring the association of the processing of these emotions to left amygdala activation, as suggested in the related literature. As psychopathy has other deficits that are not supported by amygdala functioning, the authors suggest that this emotion-specific deficit might not be explained just by functional impairments in this structure, and there may not be an issue of deficit but that its activation can potentiate other processes and mechanisms that lead to this behaviour. In terms of task-related features, deficits are enhanced when needed a verbal processing of the expression, contrarily to a non-verbal task like selecting the emotion expression through a button, and that age and sample type (e.g. non-criminal vs criminal) do not significantly influence the results.

The most recent meta-analysis is from Dawell, O'Kearney, McKone and Palermo (2012) analysing both facial and vocal stimuli results. Only fear, happiness and surprise detection were found to have impairments in both facial and vocal stimuli, and sadness only for facial expressions, but there were found deficits in all six basic emotions and being the positive emotions deficit the biggest novelty. The amygdala hypothesis still is a viable explanation to these results, since there are studies that show its activation in every facial stimulus, although it might have a more influent role in the perception of fearful faces.

In order to understand the genesis of these idiosyncrasies in facial processing, there are some studies using younger samples, with antisocial behaviour, conduct disorders or callous-unemotional traits, all characteristics that seem to be developmentally related with psychopathy, but even those show some not consensual results. Until 1999, literature was focused in some emotional processes in children with conduct disorders, revealing their lower skin conductance and resting heart rate values (Raine, Venables, & Williams, 1990;

Fowles, 1993), less embarrassment in more externalizing children (Keltner, Moffitt, & Stouthamer-Loeber, 1995) and less gaze averting before a film with images of others' distress (Eisenberg et al., 1996). Comparing the effect of threatening images, distress cues and neutral pictures on skin conductance of children who scored high and low in Psychopathy Screening Device (PSD; Frick, O'Brien, Wootton, & McBurnett, 1994), Blair (1999) found in the highest scores a hiporesponsivity to distress cues but no group differences to human faces, as was expected from previous findings with adults. In terms of facial expressions of emotion processing, Blair and Coles (2000) saw that the ability to recognize fearful and sad faces was related to both factors of psychopathy, i.e. to the presence of anti-social conducts and affective-interpersonal deficits. Stevens, Charman and Blair (2001) found the same results, as well as less accurate detection of sadness in vocal tones. Blair and colleagues (2001), using morphing facial stimuli that were progressively increasing in emotional intensity, saw that children with psychopathic traits needed more frames to successfully recognize sadness and that they significantly made more errors detecting fear than other children, even when the morph was on its most intense form. More recently, Dadds and colleagues (2006) showed that children with anti-social behaviour failed more in recognizing neutral expressions, giving more errors than in anger, contrarily to the presence of callous-unemotional traits that were related to a poorer recognition of fear, but that was normalized when the children were instructed to pay attention to the eyes. Woodworth and Waschbusch (2008), on the other side, found that the presence of CU traits were related to deficits in sadness recognition and that actually children with conduct problems with low CU traits presented less accurate fear detection.

As we see, it is very wide the range of studies and results, in this field of research, but very few of them use dynamic stimuli or morphed facial expressions. Some of them were used in children, referred above, noting that they needed more frames of the continuum to identify sadness and fear (Blair et al., 2001). One study of Blair and colleagues (2004) tried to replicate the results found in earlier developmental stages, and they have found that the difficulty in identifying fear is still present, even in the final prototypical stages of the morph, but finding no differences in sadness detection as before. Pham and Phillipot (2010) also used morphed emotional faces, increasing intensity throughout them, comparing between controls and inmates, either psychopathic or non-psychopathic individuals. The authors found that both criminal groups were less accurate then controls in detecting the emotional category, but that the psychopathic group was the least accurate at non-amygdaline emotions (happiness, anger and disgust). As amygdala is

referred as a central structure to both facial and emotional processing, it seems relevant to expose also studies using morphs with amygdala-lesion patients, because *"*Impairments seem to emerge when participants are required to process emotional information from partial or degraded stimuli (morphs)*"* (Almeida, 2011, pp. 243). Graham, Devinsky and LaBar (2007) studied a bilateral amygdala-lesion patient the perception of three different sequences: neutral to anger, neutral to fear, and fear to anger. The major differences to the control group was on reaction-time, where the patient was significantly slower detecting either emotions, comparing to neutral frames, which shows that amygdala plays a fundamental role in emotion features of a face and its damage doesn't seem to interfere in identity process alone. Other important study was developed by Graham and colleagues, in 2006, which gives some highlights of the possibility of cortical compensating mechanisms for amygdala impairment, as a patient didn't reveal any impairment in fear and anger detection as he relied in a specific feature to accurately identify the emotion.

Although confounding, all the studies may not show a deficit in emotional facial processing, but yet a type of functioning that, combining specific amygdaline and cortical features, allows different results, or sometimes even same as controls but through different neural pathways.

The main goal of this work is to see how emotional morphs' processing varies within increased presence of psychopathic traits. Our hypothesis is that the more presence of psychopathic traits will be correlated with a different morphs' processing, in line with the association of these traits with emotional processing and identification deficits. In order to see this, it will be done an analysis of the sample answers to the emotional identification task. When correlated with psychopathy levels, we expect to see a more overall salient hysteresis effect along the psychopathy continuum, revealed by a later point of coercivity (PoC), i.e. the frame where there is a change to the new emotional category. This can be explained by the growing neurophysiological inflexibility and their cortical and more cognitive, instead of automatic, emotional identification, which will lead to the need of more frames, more approximate to the emotional category's prototype, in order to more psychopathic individuals to be able to identify it. This is supported by Blair and colleagues findings in 2001 and 2004, where this need of more frames was revealed by to different age samples, but not in a psychopathy continuum perspective. In this study, there are four emotional categories (Anger, Fear, Happiness and Sadness), which makes it also interesting to see if this processing and hysteresis effect varies depending on the emotional category. In this case, concomitant with the findings of a fear detection deficit (Blair et al.

2001, 2004, 2008; Dadds et al., 2006; Dawell et al., 2012; Marsh & Blair, 2008; Wilson, Juodis & Porter, 2011), we hypothesise that there will be a later detection of fear comparing to other categories, showed by a later PoC and an increased Point of Reminiscence (PoR), i.e. a bigger cumulative frequency in the R order's PoC. Further details on PoC and PoR will be given in the data analysis section. A graphic explanation of these concepts is in Figure 4.

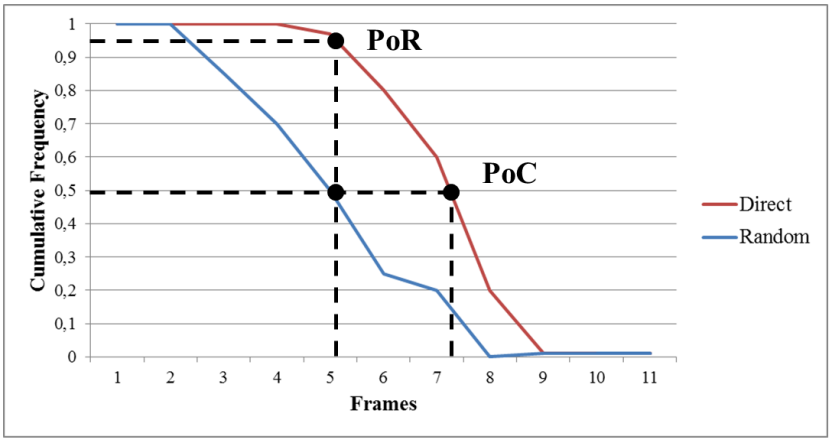

Fig. 4 Sigmoid curves of the emotional detection throughout the 11 frames of the continua. There are represented the PoC's of Random and Direct orders, showing the frames where there is a perceptive change (50% in cumulative frequencies) and the PoR of the Direct order, illustrating the cumulative frequency registered in the frame considered as the other category, in the Random Order.

Therefore, the hypothesis are:

H1: The bigger the psychopathy score, the later the next category is detected.

H2: Psychopathy scores are positively correlated with a later detection of fear.

Method

1. Sample

The participants of this study were recruited from community, through a convenience sampling. The sample comprised 29 participants, 16 female, with ages between 19 and 32 years old (mean = 22.97, *DP* = 2.93).

All participants had normal or corrected visual acuity and had sign the informed consent.

2. Material

To measure the sample's level of psychopathic traits, it was used Triarchic Psychopathy Measure (TriPM; Patrick, 2010), the most recent self-report scale used to this purpose. It is composed by 58 items, that participants shall classify on a scale from 1 (true) to 4 (false), according to his/her personality. The items divide themselves in three domains of psychopathy's construct: *boldness* (19 items*), meanness* (19 items) and *disinhibition* (20 items), and according to the author's preliminar review, each of these domains shows high correlations with the main psychopathy instruments, as well as temporal stability and predictive power (Patrick, 2010).

The stimuli were a set of facial expressions of one of the following emotional categories: Anger, Fear, Sadness and Happiness. The original stimuli are from Averaged Karolinska Directed Emotional Faces (AKDEF; Lundqvist & Litton, 1998). From the original stimuli, there were created continua composed of 11 frames, representing the evolution from one category to another, and could be from Anger to Fear (AF), Fear to Anger (FA), Anger to Sadness (AS), Sadness to Anger (SA), Anger to Happines (AH), Happiness to Anger (HA), Fear to Sadness (FS), Sadness to Fear (SF), Fear to Happiness (FH) and Happiness to Fear (HF), Happiness to Sadness (HS) and Sadness to Happiness (SH). The morphing is done with a nine percent difference between them, beginning and finishing with prototypical figures.

Fig.5 Example of the 11 frames of the continua FS (Fear-Sadness).

The stimulation device consisted of a computer equipped with the software Eprime V.2. The EEG apparatus is composed by a Electrical Geodesic's, Inc. (EGI) system, composed by Net Amps 200, a Geodesic Sensor Net and Net Station software.

3. Procedure

The data collection sessions started with a semi-interview protocol where demographic, clinical and lifestyle information were gathered in order to characterize the sample and check for factors that could lead to the exclusion of the participants (e.g., neurologic problems or use of medication affecting the CNS). Then, the participants fulfilled two psychometric concerning psychopathy: Levenson Self-Report Psychopathy Scale (SRPS ; Levenson et al., 1995) and Triarchic Psychopathy Measure (TriPM; Patrick, 2010).

The participants were then prepared for the EEG and instructed about the experimental task. They were instructed that they would visualize a sequence of facial expressions and shoud use a response device with three buttons, each corresponding to a specific emotion, to identify the emotion that was being displayed, as fast as possible time. Each frame was exposed for 500ms with an inter-stimuli interval (ISI) of 2000ms, during which the participant could press the respose key correponding to the emotion being expressed. The continua could be presented or all 11 frames could be shown stochastically (R order). The task lasted approximately 50 minutes, organized into three blocks - the first with 20 minutes, and the remaining with 15 minutes each, separated by three minutes of

rest- to prevent fatigue, and therefore the occurrence of alpha, which compromises the quality of the EEG signal. Participants could be part of one of the following conditions: Anger – Fear – Sadness (AFS); Fear – Sadness – Happiness (FSH); Anger – Happiness – Sadness (AHS); Anger – Fear – Happiness (AFH), previously defined and counterbalanced. The stimuli were presented in a 19 " monitor 1.5 meters away from the participant. The electroencephalographic data collection equipment consists of a cap 128 of the EGI electrodes (Hydrocel Geodesic Net model) referenced to averaged mastoids, with a sampling rate of 512Hz , 0.1-100Hz filtering and the reduction and maintenance of impedance will be 5 kOhms in all the electrodes. The data was recorded with NetStation software.

4. Data analysis

Participants' responses were first introduced in Microsoft Excel 2010 for pre-processing and then exported to IBM SPSS Statistics V.22 for statistical analysis. Firstly, it was constructed a data base in Excel with all participants' relative cumulative frequencies of answers for each frame, in every continua, representing the ratio between the answers of a certain emotional category and the total number of responses.

Participants' cumulative frequencies were transferred to SPSS, in which a larger data base was constructed compiling the individual TriPM scores (total and per subscale). After calculated the cumulative frequencies, several varieties were calculated. One is named PoC (Point of Coercivity), concerning the number of frames between the PoC found in the R order and the Direct order's PoC; PoR (Point of Reminiscence) from each continua, representing the cumulated frequency of the R order's PoC. In terms of statistical methods, it was used a Spearman's correlation coefficient to analyse the correlations between psychopathy scores, and the PoC/PoR values. The choice of using Spearman's was due to violation of the normal distribution, as confirmed by Shapiro-Wilk normality test.

Results

Firstly, as this work approaches emotional categorization as a non-linear process, where hysteresis effect might be present, Table 1 shows a PoC and PoR descriptive statistics for each continua. It is already possible to see that the participants take more frames to detect the next category in the continua HF and HA, and less frames in SH and FA orders, although the most reminiscence values are in FH, FS and AH.

Table 1

Mean and Standard Deviation for both PoC – number of frames between the frame where participants changed the emotional category in the R order and in the Direct order - and PoR – cumulated frequency of the answers - of each continua.

	PoC	**PoR**
FH	1.47 (1.38)	0.72 (0.35)
HF	3.3 (1.56)	0.55 (0.38)
FS	1 (1.34)	0.69 (0.32)
SF	0.19 (1.47)	0.33 (0.33)
HS	0.45 (1.13)	0.56 (0.35)
SH	-3 (1.73)	0.19 (0.25)
AF	1.07 (1.75)	0.64 (0.34)
FA	-0.32 (1.89)	0.40 (0.42)
AH	1.22 (0.67)	0.89 (0.22)
HÁ	2.55 (1.01)	0.38 (0.22)
SA	0.4 (1.84)	0.42 (0.38)
AS	1.9 (1.37)	0.36 (0.41)

Spearman's correlation coefficients between psychopathy, namely total scores and its three factors (boldness, meanness, and dishinibition) and the PoC seen in the continua (more precisely the difference between them and the PoC of the random frames) are displayed in Table 2. Psychopathy's total score shows a significant positive relationship with AF (r = .54, p = .04, FDR corrected), meaning that as the prevalence of psychopathic traits increases, the detection of Fear tends to occur later in an Anger-Fear continuum, reflected in the number of frames needed to it. Psychopathic traits represent approximately 30% of the variability of the PoC for this continuum (R^2 = .30). It was also found a negative significant relationship between higher scores of the subscale Boldness and AS' PoC (r = .80, p = .01, FDR corrected), representing the same effect described above and explaining 64% of the variation in the delay in the point of change from Anger to Sadness (R^2 = . 64).

Also a product of a Spearman's correlation coefficient is Table 3 which represents the correlation again between TriPM total scores, the subscales' results and PoR.. The results show a negative relationship between boldness and AH's (r = -.80, p = .04, FDR corrected), representing that higher scores explain in 63% (R^2= .63) a quicker change to Happiness, and consequently a lower number of Anger responses, in the AH continua's correspondent PoC. The same subscale is significantly related with the variable AS (r = .78, p = .03, FDR corrected), which in this case is a positive relationship and embodies a more prevalence of Anger responses in PoC's frame, against Sadness categorization, explaining its variability in 61% (R^2 = .61).

Table 2

Correlation between TriPM subscales - Boldness, Meanness (tripm_meann) and Disinhibition (tripm_disin) -, total TriPM score and each continuum PoC. Letters represent emotional categories (F – Fear; S – Sadness; H – Happiness; A – Anger) and letter order represent the direction of the continua (e.g., FH – from Fear to Hapiness)

	FH (*n* = 18)	FS (*n* = 21)	HS (*n* = 11)	AF (*n* = 14)	AH (*n* = 8)	AS (*n* = 10)	HF (*n* = 19)	SF (*n* = 21)	SH (*n* = 11)	HA (*n* = 8)	SA (*n* = 10)	FA (*n* = 18)
Boldness	.349	.051	.408	.085	-.420	**.802****	.068	-.169	.257	.019	-.312	.326
Meanness	.019	-.106	-.194	.434	.341	.127	-.207	-.057	.050	-.180	.362	.084
Disinhibition	-.079	-.100	.180	.282	.499	-.038	-.058	-.115	.230	.043	.059	-.415
Total	.163	-.049	.219	**.544***	.341	.403	-.016	-.157	.210	-.180	.095	-.081

*Note. *p < .05; **p < .01 (FDR Corrected)*

Table 3

Correlation between TriPM subscales, total TriPM score and each continuum PoR.

	FH (*n* = 19)	HF (*n* = 19)	FS (*n* = 21)	SF (*n* = 21)	HS (*n* = 11)	SH (*n* = 11)	AF (*n* = 18)	FA (*n* = 18)	AH (*n* = 8)	HA (*n* = 8)	AS (*n* = 10)	SA (*n* = 10)
Boldness	.357	.336	.039	-.114	.209	.428	-.172	-.175	**-.796****	-.193	**.782****	.250
Meanness	-.147	-.030	-.191	-.021	-.426	-.085	.414	.397	-.137	-.012	.167	.211
Disinhibition	-.059	-.059	.057	.059	-.094	.509	.202	.322	-.027	.012	.043	-.237
Total	.146	.093	-.001	-.027	-.099	.449	.314	.379	-.137	-.048	.423	.079

*Note. *p < .05; **p < .01(FDR Corrected)*

Discussion

On the present study, we have evaluated how psychopathy (and its dimensions) influence and explain different emotional processing patterns. The literature about emotional facial processing in psychopathy is extensive, but few regard dynamical facial stimuli processing. Also, there are still few studies crossing this issue and not only the instrument used in this work to access psychopathy, as also the assumption of psychopathy with a continuum and not categorical perspective.

The findings were both consensual and contradictory with the previous literature. Regarding the number of frames needed to "jump" to the second emotional category of the morph, the necessity of more images to detect certain emotional category implies the need of it to be nearer and more alike the prototypical configuration of the emotion itself. The hypothesis about this issue defended that higher scores of psychopathy were associated with a more salient hysteresis effect, i.e. that the number of frames needed to change its CP would be larger throughout the psychopathy continua. The results would therefore be representative of psychopathy's inflexibility and rigidness, making the perception remain in the first category until the next one is obvious and almost in its prototypical way. More specifically, it was also hypothesized that this effect would be more significant when the second emotional category is fear. In order to see this, were calculated the number of frames spent in the transition between categories in the morph and how present were the first emotional category in the expected transition frame. In terms of the total score of psychopathy, it was found that a more presence of these traits conducts to the need of more frames to detect fear after seeing anger. These results are, in some way, related to the findings in the literature. The most salient aspect of these results seems to be in the fact that this need of more frames are present in fear and sadness, the two most well-studied emotions in psychopathy and pointed out as the most deficiently processed (Blair et al., 2001, 2004, 2008; Dawell, O'Kearney, McKone, & Palermo, 2012; Wilson, Juodis, & Porter, 2011). Most specifically, there are also these findings using morphed stimuli, as Blair and colleagues (2001) in children, that found a needing of more frames to detect both sadness and fear, and later in 2004 in an adult sample, but finding deficits just in fear. This fear deficit shows to be related, in our results, with psychopathy's total scores, which will

encounter the data described above by Blair's work. It was also found that the presence of more boldness traits was associated with the need of a bigger number of frames in order to detect sadness, when confronted before with images of anger. This subscale's specificity seems to contrast with Blair and Coles' work (2000), where they saw that the ability to recognize fearful and sad faces was related to both anti-social and affective-interpersonal facets of psychopathy. Nevertheless, this facet of psychopathy describes a quick and efficient adaptation to unfamiliar and dangerous situations, being an expression of a fearless genotypic disposition of these individuals and associated with responsiveness of lower brain structures responsible for environmental evaluation, emotional processing and danger perception, as amygdala (Patrick, Fowles & Krueger, 2009; Vaidyanathan, Patrick, & Bernat, 2009). Although very know by its hyperactivation in fear processing, amygdala is associated with sadness processing also by the knowledge of its activation during feelings of sadness (Drevets et al., 1992; Schneider et al.,1997). Beside this, anger, the first emotional category of the continuum, represents a non-amygdaline emotion (Pham & Phillipot, 2010). Added with an amygdalin deficient functioning, the quick and efficient transition of pathway and structural activation from a non-amygdaline to amygdaline emotion is highly compromised.

Meanwhile, the same psychopathy indexes were correlated with the prevalence of the first emotional category during the continuum in the facial frame that was defined as uncertain in the R order, expecting higher values for higher psychopathy scores and for the continuums that would evolve to Fear, representing its still far perception to the participants. There was no relationship with total psychopathy scores. The most significant relationships were found with Boldness, again with the reminiscence of anger above sadness detection, which confirms the outcomes of the previous analysis, and negatively with the reminiscence of anger above happiness, i.e. higher boldness values relate with a quicker change to happiness. This last result meet the literature, that shows that are both non-amygdaline and the transition to one another seems more effortless (Pham & Phillipot, 2010). Additionally, these categories' processing, being happiness the most consensual (Morris et al., 1996), doesn't rely in amygdala's functioning as much as other emotions and its damaged individuals can still detect it (Adolphs, 2002). Finally, these findings are reinforced by the absence of consensual deficits in happiness processing associated with psychopathy's general or subscale in the literature.

Independently of the emotional categories where has been seen a more salient hysteresis effect, it seems clear that the negative emotions and the most associated with amygdala functioning showed, more reminiscence, as Anger, and more delay in its detection when presented in second place, as Fear and Sadness. This can be related with the use of more cortical pathways in emotional perception, especially when facing emotional categories that are more related with amygdaline functioning, deficient in psychopathy as defended by several authors. This cognitive and non-automatic emotional processing can therefore be responsible for the longer reminiscence in initial percept and the later detection of the new one, as it demands more effort in detecting the subliminar changes and it only seems clearer when the continua is closer ti its prototypical form. The possible use of compensatory mechanisms for automatic deficits, particularly in emotional information processing, in psychopathy is already shown in literature (e.g. (Intrator et al., 1997; Kiehl et al., 1999).

Conclusions

Psychopathy has been approached in a categorical and dichotomous way, as present or absent. On the other side, facial processing is commonly studied throughout the presentation of individual facial stimuli. The greatest innovations of this work are in both themes. Firstly, this research analyses psychopathy as a combination of personality traits, and, consequently, existent in every individual. Hence, it is approached here as a continuum variable, where its presence is guaranteed but its quantity varies inter-individually. Regarding facial processing, the novelty is in looking at facial processing as a non-linear phenomenon and analysing concepts as hysteresis and reminiscence as new indicators to characterize the pattern of categorical perception's variation with psychopathy. Therefore, two new ways of studying these theme were used and combined to give a total revolutionary research.

Although its results are explainable and reasonable, there were other expected outcomes that weren't found in this work, specially a more salient influence of psychopathy in the hysteresis effect. As already described, it was expect an association between psychopathy scores and a greater delay in the next category's perception, due to not only their presupposed deficits in emotional recognition and the use of more cognitive, and therefore retarded, pathways. The absence of significant results can be due to the reduced sample size, resulting in a little number of participants for each experimental condition. Also related with sample size is the reduced range of psychopathy scores, which compromise its significance in emotional results. The experimental protocol also might influence the results, since every participant has to visualize the continua, each with 11 frames, in a direct, inverse and random order, and so, although every frame is shown hundreds of times during the experiment, each order is not, which gives us also a reduced sample of each continua. Compounding this situation, the long duration of the task compromises the integrity of the last continua visualized and the results, increasing the missings and error ratings. Finally, the lack of literature regarding the psychopathy assessment instrument, TriPM, is also a point of uncertainty about psychopathy scores and their meanings.

These issues are after all positive points that reflect the innovation of this work and that represent a starting point to new ways of evaluating both facial processing and psychopathy. The biggest surprises were the correlations with the psychopathy's domains, that weren't regarded in the formulation of the hypothesis but that gave the results an interest development. Thus, it is one of the suggestions to further investigations in the area – approaching which is the influence of each subscale in emotional processing, will contributing not only to the richness of the literature about this still new instrument but also to understand more clearly the causes and/or effects of specific personality traits in the described emotional deficits or enhanced competence of psychopathy, described in literature as divergent. To improve this acknowledgment, it would be also useful the analysis of the EEG data recorded at this work. There is still few research about the neural pattern of non-linear processing, and it would be valuable in facial processing knowledge, even in the lowest scores of psychopathy to understand the phenomenon itself. In this field of analysis, we suggest the study of Event-Related Potencials (ERP's), specially N250, and a frequency analysis approach, looking at frontal gamma's variations. The N250 is a temporo-occipital negative component, peaking around 250 ms after the stimulus, associated with the visualization of familiar faces (Tanaka, Curran, Porterfield, & Collins, 2006). This component shows a decreased amplitude when are presented different faces comparably to the previous ones (Zheng, Mondloch & Segalowitz, 2012). In this study, it should present a lower and more constant N250 with higher psychopathy scores, matching their uncertainty in emotional facial recognition. Gamma is a 40Hz to 200Hz activity described in literature as, when in frontal locations, is associated with multi-stable stimuli processing and shows power enhancement during the perceptive changing (Tallon-Baudry & Olivier Bertrand, 1999).

Although its need of improvement and advance, this study was innovating in every approach and opens doors for a change in emotional perception and psychopathy, in order to step out of the criminal and categorical perspective of it, and demystify the great variability of results that cross psychopathy and emotional processing.

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